

Irreversibility in climate action

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Although climate action is undermined by political interests and institutional inertia, multiple safeguards are in place to prevent backsliding on progress so far, and positive feedbacks reinforce progress despite opposing forces. Key elements of climate action are irreversible and can be further strengthened by commitments, investments and positive narratives.

There is a growing political divide with forces at work, such as the deliberate efforts by the current US administration to weaken climate policies, discredit climate science and promote fossil fuels, which is cause for concern. This creates uncertainty in the direction of long-term policy to tackle climate change, which undermines the investments needed to drive decarbonization. Nevertheless, ambitious climate action is well underway and continues to evolve under the auspices of the Paris Agreement. Policies and investments have driven rapid cost reductions in renewable energy and batteries, while expanding the deployment of a range of low-carbon technologies.

The energy and land-use systems responsible for greenhouse gas emissions are path-dependent¹. They are constrained by 'lock-ins' that create inertia and stability. Lock-ins arise when technologies, infrastructures, policies and norms reinforce each other. When boundary conditions change through technological advances, increasing competitiveness, policy reforms or changing social values, systems can pass a tipping point and shift to a new equilibrium that is not easily reversed, provided these conditions remain in place². For instance, positive techno-economic tipping points³ have been passed or are imminent for the decarbonization of electricity and the electrification of surface transport, and citizens consistently support climate action worldwide (<https://peoplesclimate.vote>).

Here, we argue that irreversible progress in climate action is evidenced by the backstops in place to prevent regression on achievements so far, and by positive feedback mechanisms that reinforce progress in spite of opposing political forces (Fig. 1).

Backstops preventing regression

To prevent regression, stabilizing mechanisms are needed to maintain positive change. One such mechanism is the steady accumulation of more than 5,000 climate and energy laws and policies across 200 countries (<https://climate-laws.org>). The effectiveness of national climate policy portfolios comes from their increasing scope and stringency⁴, and from their focus on emissions-intensive sectors and instruments tailored to national contexts⁵. This large body of climate policies includes regulations, standards and incentives that steer market activity and infrastructure development towards climate goals. Iterative

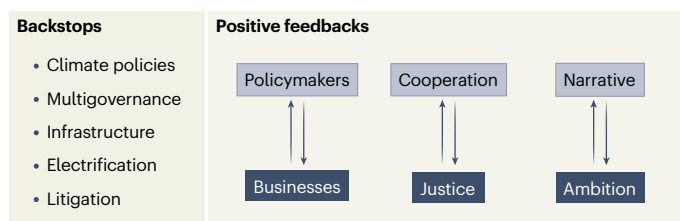


Fig. 1 | Mechanisms that sustain irreversibility in climate action. Backstops (left) and positive feedbacks (right) reinforce progress and prevent regression of climate action.

learning identifies which policies work best and diffuses and reinforces momentum through international networks and institutions.

The dispersal of public authority across multiple levels of governance also supports a myriad of protective mechanisms that provide resistance against regression. These include legal mandates agreed at higher levels of governance (for example, the European Union), making them harder to repeal domestically. Likewise, interactions between national and sub-national levels, and between states, local authorities and cities, can also act to oppose rollback of climate policy measures. For example, when the German national government diluted the enforcement of their climate action levers in 2024, several states enhanced their own rules⁶. Similarly, when President Trump withdrew the USA from the Paris Agreement, states and city governments announced with major companies that they will adhere to Paris Agreement targets, despite the national reversal⁷. This effect is not guaranteed, and multiple levels of governance could also block progress. However, the strong citizens' desire for climate action, with 72% of people globally wanting to move away quickly from fossil fuels and 80% wanting their country to do more (<https://peoplesclimate.vote>), helps orient integrated efforts in the long-term towards the strengthening of climate action.

A further backstop is long-lived infrastructure that supports low-carbon and resilient development that locks in patterns of development. Not only are these capital investments hard to reverse but they also shape the development of industry and future priorities. Renewable energy infrastructure supplies electricity at very low marginal cost, making it the first choice for power purchasing in many geographies. Upgrading of transmission infrastructure facilitates decarbonization of energy, even while there is still some fossil fuel electricity in the grid. Battery storage costs have declined while stabilizing variable renewable energy supplies and adding value to storage investments. Energy efficiency standards for buildings and appliances have driven down energy demand in many advanced economies in recent decades⁸. Despite progress, low-carbon economic development is not yet fully locked in. Many investments have harmful implications for climate, and the existing stock of fossil fuels-based energy infrastructure is sufficient to breach the Paris Agreement's temperature goals⁹.

Nonetheless, electrification is a stabilizing factor by itself. It is efficient, clean at the point of use, reliable and highly versatile: electric vehicles (EVs) are three times more efficient than combustion engines and heat pumps outperform gas boilers by the same margin. EVs and solar photovoltaics (PVs) demonstrate positive returns to scale: as adoption increases, costs fall, mass production expands and network effects accelerate market uptake. Half of the new vehicles sold in China in 2024 were EVs, as were 95% of those sold in Norway where EVs cost the same as or less than comparable internal combustion engine vehicles at the point of purchase. Technological advances mean most energy-using activity in most sectors can be electrified with net economic benefit. This includes surface transport, heating and many industrial processes, even in energy-intensive industries such as steelmaking. The electrification of economies is moving faster in China and India than in the Global North¹⁰.

Another backstop is climate litigation, which helps to prevent policy backsliding particularly where statutory laws anchor government commitments. Recent examples include the Urgenda ruling in the Netherlands, the EarthLife case in South Africa and the Finch judgement in the UK. The cumulative risk of filing cases alone provides incentives that hold governments and corporations accountable, even if it sometimes encourages a ‘race to the regulatory floor’. Litigation is also dynamic: as liabilities mount, it ratchets up pressure over time, making inaction increasingly costly. Despite difficulties in establishing clear causal linkages between rulings and long-term policy resilience owing to limited evidence, creative use of the law offers incentives and consequences that help lock in climate progress and resist reversal. The recent advisory opinion by the International Court of Justice that concluded that states have a legal obligation to act on climate change will further reinforce this backstop.

Taken together, these policy, governance, legal and technological developments are both driving and stabilizing climate action, preventing backsliding into high-carbon pathways. Electrification and renewable energy infrastructure create path dependencies that shape future development. Climate policy portfolios and multi-level governance structures endure beyond political cycles and single government terms.

Positive feedbacks reinforcing progress

In addition to backstops, multiple feedback loops and mechanisms are in place to reinforce progress. For instance, policymakers set the rules and incentives that guide economic activity. Companies, in turn, can accelerate policy-driven change through innovation and also shape policy itself, for example by influencing public investments (for example, for the infrastructure to charge EVs) or the design of policy instruments (for example, norms and incentives). Such feedback mechanisms rely on a critical mass of actors around shared ambition. Initiatives such as Race to Zero, the Earth Investment Engine and Mission Possible Partnership de-risk the transition by pooling efforts, encouraging further participation and unlocking innovation. Artificial intelligence could further accelerate solution discovery by enabling breakthroughs in materials science and improving resource efficiency¹¹. However, a strong governance framework is needed to ensure positive artificial intelligence contributions to climate action while limiting rebound effects and induced demand for energy.

International collaboration and interorganizational knowledge transfer also accelerate the adoption of new technologies and trust. Networks such as C40 cities and the CDP demonstrate how locations are keen to learn from each other¹². They encourage knowledge transfers of new technology, share learning from failed projects, and increase trust in technologies and knowledge transfer relationships¹³. However, ensuring

that transformations address issues of social justice and equity¹⁴, such as the lead pollution associated with off-grid solar technology in Malawi or the effects of lithium mining in the Democratic Republic of the Congo, is necessary to remove friction, resulting in smoother positive feedbacks.

Not all feedback mechanisms are technical or institutional – they also lie in the stories told by societies, industries and individuals. Narratives shape whether people and communities see change as possible, desirable and necessary. ‘Doom loops’ emphasize inadequacy and failure, creating apathy, anger and disengagement. By contrast, ‘ambition loops’ highlight strengths and the potential for improvement, inspiring action and cooperation. Narratives are also a powerful tool to help interpret the future and reconceptualize the world. Stories that envision a positive, achievable future are themselves feedback loops: they engage people, integrate into documents, foster collaboration, attract investment and build the collective will to act. They normalize climate action, penetrate industry and curricula, inspire young talent, and stimulate attachment to place and nature.

The presence of backstops and positive feedbacks secures the progress made so far in curbing global CO₂ emissions, at least in the short term. Global CO₂ emissions have undergone a marked shift from strong annual growth of about 2% in the decade preceding the 2015 Paris Agreement to a much slower rate of growth below 0.5% since the Paris Agreement. This slowdown has substantially lowered projected warming this century, from roughly 4 °C to below 3 °C. Although we argue that a reversal of this progress is unlikely, bringing emissions on a path towards net-zero CO₂ – as is needed to stop further warming – will require substantially more action and investment. The framing of the collective response to climate change is crucial for achieving the necessary speed, scale and uptake of climate actions around the world.

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C.L.Q., A.E.R., C.W. and N.T. conceived the commentary. C.L.Q. led the writing and editing of the text. All authors provided content and wrote and reviewed the text.

Competing interests

C.L.Q. is a member of the Scientific Advisory Council of Société Générale and of the UK Climate Change Committee (CCC). N.T. chairs the CCC and is co-CEO at Ambition Loop. J.W.H. is a member of the Expert Advisory Council of the UK National Infrastructure and Service Transformation Authority. These institutions had no role in the preparation of this Comment, which does not necessarily represent their view. The remaining authors declare no competing interests.